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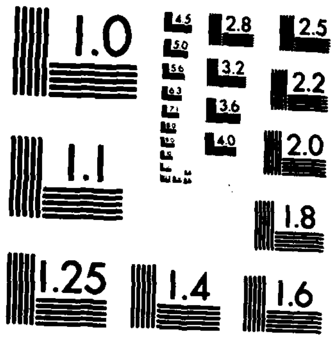

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AEROBIC/CALISTHENIC AND AEROBIC/CIRCUIT WEIGHT TRAINING PROGRAMS FOR NAVY MEN: A COMPARITIVE STUDY

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SUMMARY

In an attempt to develop conditioning programs that better align personnel physical capabilities with shipboard physical fitness requirements, two research studies were conducted to compare experimental aerobic/circuit weight training with standard aerobic/calisthenic training.

Study I - Participants were 43 Navy men ($\bar{X}$ age = 32.1 yrs) assigned to one of three exercise protocols: aerobic/circuit weight training performed at either 40 or 60% of determined one repetition maximum strength or aerobic/calisthenic training. During the 10-week study each exercise group participated in three training sessions per week performed on alternate days.

The results of this study indicate that dynamic strength (both upper and lower) increased for the aerobic/circuit weight training groups but not for the aerobic/calisthenic group. With the exception of bench press endurance for the aerobic/calisthenic group, all groups showed significant increases in muscle endurance and stamina. No significant changes were seen in static strength or flexibility in any of the groups.

Study II - Subjects were 87 male Navy personnel ($\bar{X}$ age = 19.8 yrs) receiving basic training at the Recruit Training Command, San Diego, CA. One company of recruits (N=41) participated in an experimental aerobic/circuit weight training program at 70% of determined one repetition maximum. A second company (N=46) received the standard Navy recruit physical training program (aerobic/calisthenic training). During the 8-week study both groups participated in an identical running program performed 3 times per week on alternate days. Additionally, aerobic/circuit weight training participants completed 2 circuits (1 circuit = 15 exercises) 3 times per week on alternate days to running.

Study findings show the experimental aerobic/circuit weight training program produced significantly greater dynamic muscular strength and endurance changes than the standard aerobic/calisthenic program. Recruits following the standard training program showed decrements in several muscular strength and endurance measures.

These data suggest that current Navy aerobic/calisthenic programs appear to be ill-suited for development of muscular strength fitness. A physical conditioning system consisting of approximately 15 minutes of circuit weight exercises performed three times per week appears to be a more appropriate means of enhancing muscular strength and preparing Navy personnel for muscularly demanding shipboard work.

INTRODUCTION

A Department of Defense directive has recently ordered each military service to evaluate current methods of physical conditioning and design, if necessary, programs that more effectively meet the specific physical requirements of their personnel (DOD Directive 1308.1). In the Navy, current physical conditioning guidelines (OPNAVINST 6110.1A) have emphasized the development of primarily aerobic fitness and flexibility to achieve physical readiness. However task analyses carried out onboard Navy vessels, have identified upper torso muscular strength as a critical limiting factor in performance of both general shipboard and many occupation-specific tasks. The most muscularly demanding task level activities have been characterized as involving such basic body efforts as lifting, carrying, pushing, pulling, and torquing (Robertson, 1983). The apparent mismatch between defined shipboard physical requirements and fitness attributes targeted by recent physical conditioning programs has directed research efforts towards the development of a more comprehensive, job-relevant physical training system.

In an attempt to shift the focus of the Navy's physical conditioning programs, a systematic routine of circuit weight exercises has been suggested as a means of supplementing the continuous running curriculum. While aerobic exercise serves to promote cardiovascular health the major objective of the circuit weight format will be to enhance physical readiness by improving job-related muscular strength abilities. It is anticipated that this physical conditioning system will particularly aid Navy personnel working in muscularly demanding deck, engineering, construction, and aviation billets to carry out assigned duties with less risk of sustaining lower back or other job-related sprain and strain injuries (Marcinik, 1981).

In order to assess the value of physical training for enhanced physical readiness, we are reporting the results of two studies conducted at the Naval Training Center, San Diego (NTC). A pilot study was conducted utilizing NTC staff personnel to contrast fitness changes following the Navy aerobic/calisthenic (A/Cal) outlined in the now-superseded OPNAVINST 6110.1A with two experimental aerobic/circuit weight training (A/CWT) programs of differing intensity. The results of this initial investigation were extended to a younger population in a second study which compared fitness changes in Navy recruits training at NTC following the standard recruit physical training program (based on the A/Cal program described in OPNAVINST 6110.1A), with recruits following an experimental A/CWT program. The primary objective of these two investigations was to compare standard Navy A/Cal conditioning with A/CWT methods for development of occupationally relevant muscular strength and muscular endurance.

MATERIALS AND METHODS

Training Program

Study I - Participants in the initial study were 43 male staff personnel between 24-45 years of age ($\bar{X}$ age = 32.1 yrs) stationed at the Recruit Training Command, San Diego, CA. Personnel were assigned to one of three exercise protocols: 1) Aerobic/Circuit Weight Training at 40% (A/CWT-40) of maximum strength determined for a single repetition (1RM) of the lifting exercises (N=19); 2) Aerobic/Circuit Weight Training at 60% (A/CWT-60) of determined 1RM strength, (N=16); and 3) Aerobic/Calisthenic Training (A/Cal), (N=8). Each training group participated in three training sessions per week, performed on alternate

days. During the 10-week program all groups pursued an identical running program. Bouts of running progressed from an initial 1 mile run performed at an 11 minute/mile pace to a 2.0 mile run completed in 18 minutes. Circuit weight training was performed on a 10-station Universal® gym working at an intensity of either 40% or 60% of determined 1RM strength. Two circuits (1 circuit = 11 exercises) were performed each training session interrupted by the endurance run. During each bout of CWT subjects rotated from station-to-station following a cycle of 15 sec of work at a station and 15 sec to move to the next station. Specific exercises included the bench press, shoulder press, hip flexion, knee extension, pull-up, arm curl, lat-pulldown, leg press, dips, sit-ups performed on a Universal® gym and an additional handgrip station. The 1RM for the weight exercises was re-evaluated after 5 weeks of training to adjust for strength changes. Calisthenic training included the following exercises: sit-ups, push-ups, flutter kicks, 8-count body builders (squat thrusts), and jumping jacks. The number of calisthenic exercises increased progressively during the training period (OPNAVINST 6110.1A). Training sessions consisted of calisthenics followed by the aerobic run.

Study II - Participants in the second study were 87 male Navy personnel between the ages of 17-31 ($\bar{X}$ = 19.8 yrs) receiving basic training at the Recruit Training Command. Recruits were drawn from two training companies. One company (N=46) participated in the standard Navy recruit physical conditioning program for men. Each exercise session consisted of approximately 10 minutes of flexibility and calisthenic exercises followed by an endurance run performed on alternate days 3 times per week. Runs were progressive in nature, extending from a 1.5 miles without time requirements in week 1 to 2.25 miles performed at an 8-minute/mile pace in week 8 (Instructor's Guide for U.S. Navy Recruit Training). Calisthenics consisted of sit-ups, push-ups, flutter kicks, 8-count body builders, and jumping jacks.

A second company (N=41) followed an experimental A/CWT program. This company followed the identical running program as standard trainees. In lieu of the calisthenics, however, the experimental group performed CWT exercises. Two circuits (1 circuit = 15 exercises) were performed each training session. During the CWT sessions subjects rotated from station-to-station following the same 15 sec work/15 sec rest cycle as in the initial study. Specific exercises included the bench press, shoulder press, hip flexion, knee extension, pull-up, arm-curl, lat-pulldown, leg press, arm dips, inclined sit-ups performed on a Universal® gym and, handgrip, push-ups, flutterkicks, 8-count body builders, and jumping jacks performed at ancillary stations. Work on the weight machine was performed at 70% of the 1RM for each exercise. Weights were readjusted during the fourth week of training to account for changes in strength.

Fitness Assessment - To determine alterations in fitness parameters associated with participation in the training programs, individuals underwent a physical fitness evaluation prior to and following completion of the training periods. The evaluation consisted of a battery of tests to measure dynamic and static muscular strength, muscular endurance, stamina, and flexibility described below. In Study I, the complete battery was given. In Study II only muscular strength and muscular endurance abilities were measured.

Muscular strength - Muscular strength (the maximal force which a muscle or set of muscles can generate) of the subjects was determined utilizing both dynamic and static strength measures. Dynamic strength was measured as the 1RM for the following exercises on the

Universal® gym: bench press, shoulder press, lat-pulldown, arm curl, leg press, and knee extension. One repetition maximum was determined by increasing the loads by single weight plate increments starting from a designated weight value for each exercise. The time allowed between successive trials was that required to readjust the pin which supported the weights (5-10 secs).

Static strength of the upper torso was assessed by a 2-arm lift test utilizing a Chatillon dynamometer (Robertson, 1983). The subject was instructed to hold a handle by its side bars and lift while keeping his back and legs straight and heels flat on the deck. Chain length was adjusted so that the bottom of the subject's forearm was horizontal to the deck surface with fists vertical and elbows at sides. Two trials were administered to each subject and the mean of the two trials was recorded. Static strength of the arms and shoulder muscles was also assessed by a 1-arm pull test utilizing a Chatillon dynamometer (Robertson, 1983). The subject was instructed to pull a handle while bracing the other hand on a pole. Two trials were performed for each arm and the highest mean arm score recorded.

Muscular Endurance - Muscular endurance (the ability of a muscle or group of muscles to sustain submaximal contractions) was assessed by determining the number of repetitions a subject could perform at 60% of their 1RM for that exercise. Muscular endurance of the upper and lower torso were measured with bench and leg press exercises respectively. Muscular endurance of the trunk was estimated from the maximum number of bent knee sit-ups an individual could perform within a period of 90 sec. (This measure was only determined for Study I participants).

Stamina - A combination of aerobic fitness and muscular endurance, stamina was assessed as maximal work capacity on a Monark bicycle ergometer using protocol developed by a NATO research study group (Myles and Toft, 1982). Subjects were instructed to pedal at a constant rate of 76 RPM against a progressively increasing resistance for as long as possible. Warm-up lasted for a period of two minutes against a resistance of .5 Kp. Thereafter, every minute the resistance was increased by .5 Kp. The test was ended when the participant had not maintained 76 RPM for 10 sec. Maximal work output was measured as total kiloponds of work produced during the test.

Flexibility - This component of fitness is defined as the extent of mobility about a joint. Flexibility of the lower back was assessed by a sit and reach test. The subject was seated with legs extended, knees locked and feet placed against a vertical wood board. A measuring tape was placed on a board at right angles to this board and the subject was instructed to bend forward at the waist with arms and fingers extended as far forward as possible. Three trials were administered to each subject and the highest value recorded.

Analysis Procedures - Differences in fitness changes between programs in each study were assessed by analysis of covariance (Tatsuoka, 1971). The analysis was performed using the "Statistical Package for the Social Sciences" (Hull and Nie, 1981), with the initial values of the individual fitness measures as covariates. "Adjusted values" (Walker and Lev, 1953) of fitness measures are reported to remove differences in pre-training fitness measures between groups. In those instances for which analysis of covariance did not yield parallel within-group regressions, Johnson-Neyman regions of significant differences between regression lines were computed (Rogosa, 1981). However in each case where non-parallel regressions were identified, the regions of significant difference lay beyond the range of

measured values. As a result the pooled between-group regression coefficients were used in the determination of "adjusted means" for each variable. When significant ($p<0.05$) group differences were observed, Scheffe's specific-comparison test was used for post-hoc comparisons of adjusted post-test means between groups (Linton and Gallo, 1975). Within group pre-post training differences in fitness were assessed using the t-test for correlated means (Linton and Gallo, 1975). Statistical significance was set at $p<0.05$.

RESULTS

The results of Study I are summarized in Table I. Listed are the initial mean value for each measure across all groups and the final "adjusted" means for each group with the percentage change from the initial value represented by each final adjusted mean. The table also provides the F statistic from the analysis of covariance. A significant F in this case implies a difference in the training response among groups.

In general, dynamic strength (both upper and lower torso) increased significantly for the A/CWT groups, although there were no significant differences in dynamic strength increase between the two groups. Dynamic strength did not change significantly for the A/Cal group. With the exception of bench press endurance for the A/Cal group, all three groups showed significant increases in muscle endurance and stamina. Changes in bench press muscle endurance were significantly greater for the A/CWT-60 group than for the A/Cal group. No significant changes were seen in static strength or flexibility in any of the groups.

Table II provides the results of Study II, the recruit training sample. As in Table I, initial and final adjusted means are provided along with the percentage change for each variable. Again the F statistic for the analysis of covariance is provided.

The experimental A/CWT program for recruits produced significant gains in all measures of dynamic muscular strength and endurance. The standard A/Cal program elicited differential changes in fitness. Several decrements in upper torso and lower torso dynamic strength were observed. With the exception of leg press endurance, recruits following the experimental A/CWT program displayed significantly higher muscular strength and muscular endurance scores than standard training members.

DISCUSSION

The intent of this report is to provide a general comparison of fitness outcomes produced by A/CWT and A/Cal conditioning methods. A direct comparison of training induced fitness changes between Study I and Study II is difficult. There are differences in subject variables (middle aged sedentary staff personnel vs. young active recruits), training duration (10 weeks vs. 8 weeks), training intensity (CWT-40 and CWT-60 vs. CWT-70), and exercise protocol.

The two research studies were combined in part due to the low number of A/Cal training participants in Study I. While the pre-test N for the three training groups was 25 in this study, post-test N's were 19 (A/CWT-40), 16 (A/CWT-60) and 8 (A/Cal). Several factors may have contributed to the high attrition rate displayed by the A/Cal group. Compared to A/Cal group trainees, A/CWT group members received greater supervision and each workout was closely monitored. Additionally, A/CWT participants frequently commented they found exercising on a multi-station weight machine more diversified and less monotonous than

performing calisthenic exercises. A/CWT members also expressed they favored the personalized approach of the CWT program (each individual worked at a certain percentage of their maximum strength) and felt they could see improvement as the weights increased. These factors influence motivation to exercise and may therefore influence adherence.

In general CWT produced significantly greater gains in dynamic muscular strength and muscular endurance than calisthenic training. The percentage changes seen in muscle strength and endurance following CWT are comparable to other published values for similar programs (see Gettman & Pollock, 1981). The fitness changes observed are consistent with the specificity of training offered by each of the training programs. Both dynamic strength and dynamic muscular endurance increased following dynamic strength training by the CWT groups. The Study I calisthenic training group (middle-aged sedentary staff personnel) showed no change in strength and Study II group (Navy recruits) exhibited significant reductions in several dynamic strength measures. These results seem reasonable since calisthenics did not provide as much muscle loading as did the weight training. Also, the apparent de-conditioning of the Study II recruit calisthenic group may be influenced by their higher initial fitness level when compared to the middle-aged calisthenic group. Calisthenic training apparently failed to supply a training stimulus of sufficient magnitude to even maintain strength in this younger, stronger recruit population. Study I groups showed comparable increases in stamina. This is not surprising since they all followed the same running schedule.

There were no significant changes in isometric (static) strength with any of the Study I training programs. This was unexpected since most researchers find some degree of overlap between the development of dynamic and static strength (see Clarke, 1973 for a discussion of this point). Dynamic counterparts of two of the isometric tests were practiced by the CWT groups: handgrip, and arm-curl (similar to the static arm-lift). The handgrip training involved repeated squeezing of a spring-loaded device. This exercise may not have loaded the arm muscles sufficiently to promote sufficient strength gains to be observed when measured statically. Handgrip endurance may well have changed, but it was not measured. The CWT groups did, however, show significant strength increases in the arm-curl, but none that were significant for the static 2-arm lift. There were differences in hand position (supinated for the arm-curl, vertical for the arm lift) which would affect the ability to utilize the biceps on the arm lift and might prevent complete measurement of any isometric gains. In any event it appears that the overlap in development of isometric strength following dynamic strength training is too small to result in measurable changes under these training and testing conditions. The isometric measures employed here have been suggested as part of a test battery for selection of personnel for various ratings, and significant correlations (abeit somewhat modest) have been found between performance on these isometric tests and performance of modeled shipboard emergency tasks. Therefore further inquiry into the interrelationships between isometric strength, dynamic strength, and the performance of shipboard tasks is warranted if we are to assess the real utility of physical conditioning programs such as the A/CWT programs tried here.

Significant changes in flexibility were not seen following any of the Study I training programs. None of the programs stressed flexibility development although some stretching exercises were provided. It may be that the flexibility test employed in this study lacks sufficient reliability or precision to measure any gains or losses. This aspect of our

physical conditioning programs requires further attention.

Another unexpected finding was that there were no significant or consistent differences in the strength and muscle endurance changes between the two Study I circuit weight programs, despite their different intensities. Similar results have been reported by several other investigators (pp 74-76; Clarke, 1973). It would appear that there is a similar rate of strength development for a rather wide range of submaximal loads. Several factors may contribute to this finding: 1) The weight increments on the weight machine were rather coarse (5, 10 or 20 lb. increments depending upon the exercise) relative to the initial strength measure. Rounding off to the nearest weight plate could have resulted in exercise weights that were only slightly different for equally matched participants on the 40% and 60% programs. 2) The workout weights may not have been reassessed frequently enough (once, at week 5). The workout load could actually have been less than 40 or 60% of the now-improved 1RM capacity. Low workout loads are particularily possible since the study participants were rather sedentary prior to their participation. Physical fitness gains tend to be greater when your fitness level is low (see Fig 6-3; Knuttgen, 1979).

A/CWT does seem to result in greater overall fitness gains than the previously-encouraged A/Cal approach. It also results in the strength gains suggested by others (Robertson, 1983) to be necessary for the performance of shipboard tasks. It is, however, difficult to maintain the aerobics portion of the program onboard ships. Therefore, A/CWT programs such as those tested here are likely to have their greatest utility at recruit training centers and other shore facilities where personnel are undergoing training for some of the physically demanding ratings listed previously or for maintenance of general fitness for those stationed ashore between sea rotations.

Results from other investigators suggest that CWT by itself may be adequate to maintain (or even improve for very deconditioned individuals) aerobic fitness (see Gettman and Pollock, 1981). If this is the case, CWT may offer the basis for a shipboard physical fitness maintenance program. We will evaluate such a program in our future work.

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TABLE I - MEAN FITNESS CHANGES FOLLOWING AEROBIC/CIRCUIT WEIGHT TRAINING AND THE STANDARD NAVY AEROBIC/CALISTHENIC TRAINING PROGRAM

	Initial Adjusted Mean All Groups (N=43)	Final[1] Adjusted Mean A/CWT-40 (N=19)	Final[1] Adjusted Mean A/CWT-60 (N=16)	Final[1] Adjusted Mean A/Cal (N=8)	F Value
Upper Torso Static Strength (lbs)					
1-Arm Pull	132.5	129.6 (-2.2%)	141.4 (+6.7%)	122.9 (-7.2%)	1.8
2-Arm Lift	103.5	103.7 (+0.2%)	110.2 (+6.5%)	95.6 (-7.6%)	2.4
Handgrip	81.8	79.0 (-3.4%)	85.4 (+4.4%)	77.7 (-5.0%)	2.2
Upper Torso Dynamic Strength (lbs)					
Shoulder Press	101.6	115.1 (+13.3%) *	115.3 (+13.5%) *	94.7 (-6.8%) ab	8.2 †
Bench Press	126.6	129.7 (+ 2.4%) *	135.7 (+ 7.2%) *	117.1 (-7.5%)	2.4
Arm Curl	68.8	75.2 (+ 9.3%) *	78.1 (+13.5%) *	66.7 (-3.0%) ab	7.0 †
Lat Pulldown	128.6	136.7 (+ 6.2%) *	148.3 (+15.3%) *	128.1 (-0.4%) b	6.8 †
Lower Torso Dynamic Strength (lbs)					
Leg Press	358.4	430.2 (+20.0%) *	429.3 (+19.8%) *	321.2 (-10.4%) ab	9.9 †
Knee Extension	111.7	134.6 (+20.5%) *	139.1 (+24.5%) *	108.4 (- 3.0%) ab	9.1 †
Muscular Endurance (No. of Repetitions)					
Bench Press	14.7	25.4 (+72.8%) *	27.3 (+85.7%) *	17.7 (+20.5%) b	8.9 †
Leg Press	33.1	55.1 (+66.5%) *	47.4 (+43.2%) *	38.5 (+16.3%) *	4.1
Sit-Ups	39.3	42.5 (+ 8.1%) *	42.9 (+ 9.2%) *	42.0 (+ 6.9%) *	2.4
Stamina					
Maximal Work Capacity on Bicycle Ergometer (kpm)	1458.1	1695.7 (+16.3%) *	1748.0 (+19.9%) *	1710.5 (+17.3%) *	1.5
Flexibility (in)	1.4	.84 (-40.0%)	2.9 (+107.1%)	2.9 (+107.1%)	1.9

[1] Final adjusted means shown with % change from initial means
* *Significantly different from initial mean value (p<0.05)*
[a] Significantly different from A/CWT-40
[b] Significantly different from A/CWT-60
† Significant F value (p<0.05)

TABLE II - MEAN FITNESS CHANGES FOLLOWING AEROBIC/CIRCUIT WEIGHT TRAINING AND THE STANDARD NAVY RECRUIT AEROBIC/CALISTHENIC TRAINING PROGRAM

	Initial Adjusted Mean All Groups (N=87)	Final[1] Adjusted Mean A/CWT-70 (N=41)	Final[1] Adjusted Mean A/Cal (N=46)	F Value
Upper Torso Dynamic Strength (lbs)				
Shoulder Press	116.0	125.6 (8.3%) *	100.9 (-13.0%) a*	50.6 †
Bench Press	139.8	157.0 (12.3%) *	122.7 (-12.2%) a*	101.8 †
Arm Curl	67.0	79.5 (18.6%) *	66.3 (- 1.0%) a	39.5 †
Lat Pulldown	143.1	159.7 (11.6%) *	139.1 (- 2.8%) a	21.5 †
Lower Torso Dynamic Strength (lbs)				
Leg Press	401.0	419.5 (4.6%) *	329.4 (-17.8%) a*	63.6 †
Knee Extension	146.3	190.7 (30.3%) *	165.9 (13.4%) a*	18.3 †
Muscular Endurance (No. of Repetitions)				
Bench Press	17.6	20.5 (16.5%) *	20.1 (14.2%) *	.3
Leg Press	48.7	52.7 (8.2%) *	38.8 (-20.3%) a*	13.3 †

1 Final adjusted means shown with % change from initial means
* Significantly different from initial mean value ($p<0.05$)
a Significantly different from A/CWT-70
† Significant F value ($p<0.05$)

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(U) Analyses of generic shipboard work tasks indicate that the majority of assigned duties involve heavy lifting, carrying, pushing, and pulling efforts.

Findings of this investigation show that aerobic/circuit weight training elicited significantly higher scores than aerobic/calisthenic training for the majority of upper and lower torso muscular strength measures. These data suggest that a 15-minute circuit weight training regimen be considered to augment current Navy aerobic oriented physical conditioning programs for enhanced physical readiness.

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